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RELIABILITY OF THE FOREST SERVICE TYPE RAIN-GAGE

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The Forest Service type rain-gage was originated by W. B. Osborne of the Portland, Oreg., office of the U. S. Forest Service to meet a need for reliable rainfall measurements at low cost. Many hundreds of them, over 700 on the national forests of northern Idaho and western Montana alone, are now being used during the summer months as aids to forest-fire control management. They supply the only measurements of summer precipitation on millions of acres of forested mountain watersheds. Without low-cost gages such measurements could not be afforded at most of these stations.

The Forest Service type gage is similar in form to the Weather Bureau standard type but differs from it in capacity, workmanship, and materials. It consists of a galvanized sheet iron receiver having a vertical rim that extends two inches above the funnel, a galvanized sheet iron overflow can, and an inner measuring tube of seamless brass closed at one end by a brass disk. All joints are soldered. For economy in construction, a commercial size of brass tubing having an inside diameter of 2.416 inches and a cross-sectional area of 4.584 square inches was adopted for the measuring tube. The receiver was then made to have an area just ten times greater, or 45.84 square inches, with a diameter of 7.64 inches. The capacity of the gage is one-half inch in the measuring tube and about six inches in the overflow can. During normal times these gages sold for $1.25 to $2.00, and short measuring sticks 5 to 20 cents, apiece. The sheet iron receivers become bent out of shape more readily than the receivers of sturdier gages, hence correspondingly greater care in handling is necessary to preserve accuracy. The gage may be mounted on a pipe support as shown in figure 1, or a box-type similar to, but shallower than, the one shown holding the Weather Bureau standard type gage.

Tests to determine the reliability of the Forest Service type gage have been conducted at the Priest River Experimental Forest, Idaho, the Bent Creek Experimental Forest, N. C., and elsewhere. The method of testing employed at Priest River consisted of comparing the Forest Service type with two other types that are officially accepted and used by the nation's foremost meteorological organizations. The three gages, including one Forest Service type, one Weather Bureau standard type, and one Friez tipping-bucket type, were arranged in a triangular formation with the gages 5 feet apart and the receivers all at the same height, as shown in figure 1. The Bent Creek installation consisted of two gages only, a Forest Service and a Weather Bureau standard in close proximity.

An analysis of six seasons' comparisons of the three types of gages at Priest River and one season's comparison of the two types at Bent Creek are summarized in table 1. At least two different Forest Service and two different Weather Bureau standard gages were used in the Priest River comparisons. The same gages were used, unchanged, from 1937 to 1940, but for 1941 both gages were replaced. It is not known whether the same ones were used in 1936 as in 1937–40.

TABLE 1.—*Comparison of the Forest Service and tipping-bucket type rain-gages with the Weather Bureau standard*

Place and year	Number measurements	Precipitation			Differences		Standard error of differences	
		F.S. gage	W.B. gage	T.B. gage	F.S.-W.B.	T.B.-W.B.	F.S.-W.B.	T.B.-W.B.
Priest River:		*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
1936	30	5.07	5.06	5.07	0.01	0.01	0.0175	0.0337
1937	26	7.31	7.27	7.13	.04	[1] .14	.0400	.0484
1938	43	6.08	6.06	5.88	.02	[1] .18	.0284	.0559
1939	53	7.22	7.19	6.96	.03	[1] .23	.0413	.0562
1940	55	11.11	11.05	10.81	.06	[1] .24	.0340	.0566
1941	104	18.44	18.72	18.16	[1] .28	[1] .56	.0858	.0792
Bent Creek:								
1937	19	8.45	8.40	-------	.05	-------	.0478	-------

[1] Statistically significant at the 0.01 level of probability.

The same tipping-bucket gage was used throughout. The catches of the tipping-bucket gage were measured by draining the rainfall into the measuring tube, which can be seen under the gage in figure 1, and measuring it with the usual ruled stick. Each season's comparison at Priest River lasted from approximately May 1 to October 31. The Bent Creek test was made in July and August 1937.

In five out of the six Priest River tests, the Forest Service gage agreed more closely than the tipping-bucket with the Weather Bureau standard. Furthermore, the catch (both total seasonal and daily average) of the Forest Service and Weather Bureau types differed by a statistically significant [1] amount in only one out of the six tests, whereas the tipping-bucket differed significantly from that of the Weather Bureau standard in five out of the six tests. Furthermore, the standard errors of the differences show that in five out of six tests the differences of the Forest Service gage from the standard were more consistent than were the differences produced by the tipping-bucket. In other words, the catch of the Forest Service type did not tend so much as that of the tipping-bucket type to differ from the Weather Bureau standard catch by a large amount on one day and only a small amount on another.

The Bent Creek test [2] agreed with the Priest River comparisons between Forest Service and Weather Bureau types. The Forest Service gage catch of 8.45 inches differed from the Weather Bureau standard type catch of 8.40 inches by only 0.05 inch, which is not statistically

[1] The method used to test for significance is explained on page 30 in Paterson, D. D., *Statistical technique in agricultural research*, New York, 1939.

[2] Data furnished by George M. Jemison of the Appalachian Forest and Range Experiment Station, Asheville, N. C.

significant when compared to the standard error of the difference, 0.0478 inch.

These data, which include 933 measurements of 311 precipitation days on the Priest River Experimental Forest and 38 measurements of 19 precipitation days on the Bent Creek Experimental Forest, show that the inexpensive Forest Service type rain gage is entirely dependable for all ordinary measurements of rainfall where large capacity or automatic recording is not required. Other factors such as topography and obstructions surrounding the instrument exposure may introduce deviations and errors far greater than those caused by the design or low cost of the Forest Service gage.

During the emergency caused by the war this smaller gage has other features to recommend it. It contains only a fraction of the amount of brass and iron that is required by the larger gages, and it can be built by any competent tinsmith.

PRELIMINARY REPORT ON TORNADOES IN THE UNITED STATES DURING 1942

By J. L. Baldwin

[Weather Bureau, Washington, February 1943]

These tabulations are derived from data on "Severe Local Storms" appearing in the Monthly Weather Review and in the monthly Climatological Data of the different Sections of the United States. They show the approximate monthly and annual number of tornadoes and the deaths, injuries, and property damage caused by them in the States and the country as a whole. Table 1 is a tabulation of known tornadoes and table 2 of possible tornadoes. A final and more complete report will appear in the United States Meteorological Yearbook, 1942.

Tornadoes during 1942 were normal in many respects. The greatest number in the United States for any month was 31 in May, which is almost exactly normal in respect to time and number. It is also noted that the total number reported for the year was 132, or 153 if we include the possible tornadoes, against a 27-year average of about 140; furthermore, the total damage produced by these twisters was tabulated as $11,818,400, or approximately normal.

The greatest human loss for any month was 111 killed and 781 injured in March, followed by 86 killed and 444 injured in April, while during July, August, September, and November no deaths were reported and only 3 injuries. The 335 deaths for 1942 exceeded the annual average of 265. There were 114 deaths and over 250 injuries in Oklahoma and 66 deaths and 527 injuries in Mississippi. Almost one-half of the total number of tornadoes, deaths, and property losses occurred in the four States of Kansas, Oklahoma, Texas, and Iowa.

The greatest monthly property loss, approximately $3,862,000, occurred in April of which amount $2,015,000 was at Pryor, Okla., on the 27th and $1,500,000 at Crowell, Tex., on the 28th.

The most severe tornado during 1942 and one of the most disastrous ever to strike Oklahoma occurred at Pryor, Mayes County, at 3:45 p. m., April 27. It moved northeastward over an area one-fourth mile wide and about 20 miles long. The center passed over the principal business section of the city of Pryor, demolishing dozens of frame buildings and several brick and stone buildings. Torrential rains and some hail accompanied it. The American Red Cross reported 52 killed and 181 treated for injuries. Property damage was estimated at $2,000,000. Another very severe tornado struck the southwestern suburbs of Oklahoma City at about 8:41 p. m., June 12. It dropped suddenly to the surface, moved slowly southeastward for 200 or 300 feet, curved to the southwest for another few hundred feet, recurved to the east for a short distance, then curved north, describing almost a semicircle before beginning its westward movement. Its translation was markedly slow. Very little rain and no hail accompanied the storm, but much mud was present in the funnel cloud. It caused 35 deaths, 29 serious injuries, and destroyed 73 homes and damaged 31 others. A detailed technical study of the Pryor and other recent tornadoes was prepared by the Forecast District at Kansas City, Mo.

A very destructive tornado also occurred at Crowell, Foard County, Tex., at about 9:30 p. m., April 28. It moved from the northwest, killing 11 people, injuring 250, and destroying property estimated at $1,500,000 in an area 1 by 3 miles, principally within the city of Crowell. Another severe tornado struck Berryville, Ark., at 10:30 p. m., October 29, killing 29 people, injuring over 100, and destroying 137 homes and other buildings and damaging 65 more.

The Guymon, Okla., tornado traveled from northeast to southwest contrary to the usual movement of tornadoes. Unusual movements were also noted in a few other cases, and especially by the Oklahoma City tornado mentioned above. Some of these tornado clouds traveled in series or on parallel routes during general storms and some did not reach the ground or only in places. It is interesting to note that the least destructive tornadoes reported during the year were 8 funnel clouds observed in Kansas during August in connection with 3 storms. They produced practically no damage, and it is stated that 7 of these funnel clouds did not reach the ground and that 6 of these 7 were observed extending down from the same storm cloud.

Some excellent pictures of the Lake Park, Iowa, tornado of May 30 and notes on the causes of destructive local storms are published in the Iowa section, Climatological Data of June 1942. These observed conditions agree with J. R. Lloyd's conclusion that "tornadoes appear to occur only in connection with upper-air cold fronts," and other deductions presented in his investigations that were published in the Review of April 1942, under the title, "The Development and Trajectories of Tornadoes."